SUMMARY
Utah Quaternary Fault Parameters Working Group Meeting
Tuesday, February 10, 2009
Utah Department of Natural Resources Building, Room 1010
1594 West North Temple, Salt Lake City

WELCOME AND INTRODUCTION

Bill Lund (Utah Geological Survey [UGS]) called the 2009 Utah Quaternary Fault Parameters Working Group (UQFPWG) meeting to order at 8:00 a.m. After welcoming Working Group members and guests (attachment 1), Bill summarized the UQFPWG's past activities and outlined the Working Group's purpose and goals for the future.

UQFPWG Purpose and Goals

- Helps set and coordinate the earthquake-hazard research agenda for the State of Utah.
- Reviews ongoing paleoseismic research in Utah, and updates the Utah consensus slip-rate and recurrence-interval database as necessary.
- Provides advice/insight regarding technical issues related to fault behavior in Utah and the Basin and Range Province.
- Identifies and prioritizes future Utah Quaternary fault studies.

TECHNICAL PRESENTATIONS

The following presentations were made on current paleoseismic research and related activities in Utah:

- Nephi segment, Spring Lake trenching update; Daniel Horns, UVSC
- Weber segment, Rice Creek trenching results; Chris DuRoss, UGS
- Brigham City segment, trenching update; Tony Crone, USGS
- Geologic evidence of high-stress-drop earthquakes in the Rocky Mountains; Suzanne Hecker, USGS
- Results of tomographic imaging of the proposed Power Line trench site, Washington fault zone; Jerry Schuster, UUGG

- Evaluating the seismic potential of the Joes Valley fault zone; Lucy Piety, USBR

- New Lidar data for the southern Wasatch fault; Ron Bruhn, UUGG

- Update on contemporary deformation and stress field of the Wasatch Front; Christine Puskas, UUGG

Stephanie Davi, USU, was unable to attend the meeting, so no report was made on the status of trenching studies on the East Cache fault zone.

TECHNICAL DISCUSSION ITEMS

The Working Group considered the following technical discussion items:

- Issues regarding the generalization of the surface trace of the Salt Lake City segment of the Wasatch fault on the National Seismic Hazard Maps

- West Valley fault zone, Part 1 - The “WVFZ Problem” and why it is an issue for the National Seismic Hazard Maps

- West Valley fault zone, Part 2 - Other active, graben-producing fault pairs in Utah/Basin and Range Province and issues they raise regarding the National Seismic Hazard Maps

Issues Regarding the Generalization of the Surface Trace of the Salt Lake City Segment of the Wasatch Fault on the National Seismic Hazard Maps

As mapped by Personius and Scott (1992), the surface trace of the Salt Lake City segment (SLCS) of the Wasatch fault zone (WFZ) includes two major left steps; one in Holladay at approximately 4500 South and the other in northern Salt Lake City at approximately 100 North (2nd Avenue). For the purposes of the National Seismic Hazard Maps (NSHM), the U.S. Geological Survey (USGS) bridged these gaps in surface faulting by adding connecting faults to create a single, uninterrupted trace for the SLCS (attachment 2). The USGS bridged the southern stepover by connecting the northern end of the Cottonwood fault with the southern end of the East Bench fault. The resulting east-striking fault extension is at a high angle to the trends of the two bounding faults. The northern stepover occurs between the northern end of the East Bench fault and the southern end of the Warm Springs fault, located 4 km to the west along the western edge of the Salt Lake City salient. About 2 km south of the northern stepover, the East Bench fault makes a pronounced bend to the northeast toward the University of Utah. The USGS bridged the northern stepover by adding a fault that extends west-northwestward from the East Bench fault bend to the southern end of the Warm Springs fault. In the resulting USGS fault model, the 2.8 km section of the East Bench fault north of the bend becomes part of the footwall of the SLCS.

Jim Pechmann raised the following questions regarding the USGS' depiction of the SLCS on the NSHMs:

<u>Main Question</u>

1. Should the NSHM generalization of the SLCS (Wasatch fault) be revised? If so, how?

<u>Related Questions</u>

2. Is it necessary and/or desirable for the fault traces used in the NSHM probabilistic seismic hazard analysis (PSHA) calculations to be continuous?
3. Are there subsurface connections across stepovers in normal faults?
4. What about the NSHM generalizations of the rest of the Wasatch fault—and other normal faults?

Questions 1 and 3 received the bulk of the discussion in the time available. Jim proposed alternative configurations for both stepovers in the SLCS. Jim's proposal for the southern stepover was a southeast-trending fault connection starting at the southern end of the East Bench fault, based on other fault maps and scarp height information in Personius and Scott (1992). Jim's proposal for the northern stepover consisted of a simple, straight-line tear fault connecting the northern end of the East Bench fault near the University of Utah to the southern end of the Warm Springs fault. The resulting fault has a strike of 82 degrees, dips to the south, and would be expected to have oblique-slip motion. Jim and his colleagues at San Diego State University developed this alternative fault configuration for use in modeling ground shaking from large earthquakes on the SLCS. After considerable discussion, the working group decided that additional work on the geometry (seismic or gravity geophysical surveys) and paleoseismology (trenching and cone penetrometer borings) of the northern Salt Lake City segment should be pursued before making any recommendations to the USGS.

See attachment 3 for additional written comments provided by Steve Harmsen, USGS, regarding the above questions raised by Jim.

West Valley fault zone, Part 1 - The "WVFZ Problem" and Why it is an Issue for the National Seismic Hazard Maps

In September/October 2008, the USGS adopted new normal-fault attenuation relations for use in their PSHA calculations for the NSHMs. As a result, the West Valley fault zone (WVFZ) contributes almost equally with the Wasatch fault zone (WFZ) to the ground-shaking hazard at sites on the hanging wall of the WVFZ, resulting in a spike in the short-period hazard in downtown Salt Lake City. Recognizing that this level of hazard would be controversial to many geologists, seismologists, and engineers, the USGS initiated a discussion regarding whether or not to make a change in the map before engineers voted on the maps for inclusion in the next iteration of the International Building Code. The discussion included a conference call among individuals with knowledge of/interest in the WVFZ, and continued with an extensive email correspondence among discussion participants. Due to time constraints and a lack of justification to support a more detailed model, the USGS chose to use a comparatively simple

WVFZ model for this round of NSHMs (distance from Granger fault trace to the SLCS 12 km, WVFZ truncated against the SLCS at a depth of ~5 to 8 km depending on dip angle, independent rupture of the WVFZ and SLCS, and paleoseismic slip rates as recommended by the UQFPWG [Lund, 2005] for both faults). However, the discussion identified several issues/problems regarding the WVFZ that require further investigation to refine the WVFZ fault model for use on future iterations of the NSHMs. The issues/problems included:

- What kind of fault model (independent, simultaneous, or clustered) best describes the relation between the WVFZ and the WFZ, and what are the parameters for that model?

- If the WVFZ does rupture simultaneously with the WFZ, how much, if any, moment does it contribute to ground shaking; are there good models/examples of coseismic rupture of a master and associated antithetic fault?

- Is the Granger fault or the Taylorsville fault the principal WVFZ fault, and what is the relation between them at depth?

- What is the best measurement (minimum, maximum, or average) to characterize the distance between surface traces of the Granger fault and the SLCS of the WFZ?

- Are the surface traces of the Granger fault, Taylorsville fault, and the SLCS too generalized as currently depicted on the NSHMs?

- What are the dip angles of the WVFZ and SLCS, and at what depth do the two faults intersect, if at all?

- How well constrained are the WVFZ recurrence-interval data?

- How well constrained are the WVFZ slip-rate data?

- How well constrained are the WVFZ slip-per-event data?

- What is the magnitude of a characteristic WVFZ earthquake, and what is the average displacement during a characteristic event?

- Is there a significant component of aseismic slip on the WVFZ?

- Is the WVFZ a manifestation of half graben formation on a listric WFZ?

- What new data are needed to improve the WVFZ and SLCS models?

- What about the other potentially active master/antithetic fault pairs in Utah/Basin and Range – how should they be handled on the NSHMs?

To investigate some of these questions further, the following presentations were made:

- The "WVFZ problem" and why it is a NSHM issue; Bill Lund, UGS

- Geologic and paleoseismic review of the WVFZ, geometry and paleoseismic history of the two fault strands, data quality, and evidence for coseismic rupture with the Wasatch fault; Mike Hylland, UGS

- WVFZ rupture models (simultaneous, clustered, independent, and others?); issues encountered in modeling the WVFZ/WFZ interaction, details of the model selected for this version of the NSHMs; Steve Harmsen, USGS

- How URS treats the WVFZ in their PSHAs; Ivan Wong, URS Corp

- Final WVFZ model, implications for hazard calculations, recommendations for future research to improve the model; Mark Petersen, USGS

Based on the presentations and the ensuing discussion, the UQFPWG identified two key areas of future geologic research regarding the WVFZ and the SLCS:

- Obtain additional paleoseismic information for both the WVFZ and the northern end of the SLCS (northern East Bench fault, southern Warm Springs fault, and Virginia Street fault) to better characterize the relation between surface faulting on the two fault zones. Ground motion models in the Salt Lake City area will remain tenuous until it can be demonstrated whether the WVFZ and SLCS rupture together, independently, or in some combination of those two modes.

- Define the subsurface geometry of the WVFZ and the SLCS with particular emphasis on the left stepover between the East Bench and Warm Springs faults on the SLCS, and the probable intersection of the WVFZ and the SLCS at depth.

West Valley fault zone, Part 2 - Other Active, Graben-Producing Fault Pairs in Utah/Basin and Range Province and Issues They Raise Regarding the National Seismic Hazard Maps

Closer examination of the relation between the WVFZ and the SLCS led to the realization that there are many other "master-antithetic" fault pairs in Utah and throughout the Basin and Range Province that may intersect at seismogenic (less than about 15 km) depths. In some instances determining which fault is the "master fault" and which is the "antithetic fault" appears straightforward, the SLCS/WVFZ example being a case in point. In other instances, the distinction between two faults is not obvious. The East and West Cache faults are an example of two major, range-bounding faults that dip toward each other, may intersect in the seismogenic crust, and give no clear indication of which, if either, is the master fault. Additionally, there is the example of the comparatively short, east-dipping Hansel Valley fault (HVF), which produced Utah's only historic surface-faulting earthquake in 1934, and the adjacent, much larger, west-dipping, range-bounding North Promontory fault (NPF), which shows evidence of Holocene displacement. The relation between the smaller HVF and the larger NPF is analogous to the

WVFZ/SLCS example; however, in this instance the smaller ”antithetic“ HVF produced a surface-faulting earthquake with no evidence of coseismic activity on the “master” NPF, which may truncate the HVF at depth.

To examine this issue further, the following presentations were made:

- Other active, graben-producing fault pairs in Utah/Basin and Range Province and issues they raise regarding the NSHMs; Tony Crone, USGS for Kathy Haller, USGS

- The East and West Cache Valley fault pair as an example; what do we know about the geometry and earthquake history of these two faults, do they potentially intersect above seismogenic depths, is coseismic rupture a possibility, how are they the same/different from the WVFZ?; Chris DuRoss, UGS

Based on the presentations and the ensuing discussion, it is apparent that many opposite dipping fault pairs throughout the Basin and Range Province (several examples were presented from Utah and Nevada) may intersect at seismogenic depth, particularly if the faults dip between 40 and 60 degrees as is assumed on the NSHMs, but information on the details of their subsurface geometry and comparative paleoearthquake histories is limited to nonexistent in most cases. Therefore, determining how to model such fault pairs on future iterations of the NSHMs remains problematic, and the Working Group made no specific recommendations to the USGS.

UQFPWG 2010 FAULT STUDY PRIORITIES

In 2005, the UQFPWG recommended that 20 Quaternary faults/fault segments in Utah be investigated to “adequately characterize Utah’s earthquake hazard to a minimally acceptable level” (Lund, 2005). In 2007, the Working Group recommended an additional five faults/fault segments for additional study. The UQFPWG reviews the progress made toward investigating the recommended faults/fault sections annually, and based on that review identifies a list of highest priority faults/fault segments for additional study. For 2009, the Working Group identified the Provo segment penultimate event and the WVFZ as co-first priority study targets, and elevated the previously unranked Washington fault in rapidly urbanizing southwestern Utah to the number three priority. The Carrington fault beneath Great Salt Lake and the Rozelle section of the Great Salt Lake fault (also beneath Great Salt Lake) were the number four and five priorities, respectively.

None of the 2009 highest priority faults received funding for additional study over the past year. The UGS did conduct a reconnaissance of the WVFZ to identify potential trench sites for future investigation. Based on discussions in this year’s meeting regarding both the surface-fault-trace model used for the SLCS on the NSHMs, and the relation between the SLCS and the WVFZ with regard to paleoearthquake timing and subsurface geometry, the UQFPWG identified the northern part of the SLCS (East Bench, Warm Springs, and Virginia Street faults) as a new high priority for additional study. Dave Dinter and Jim Pechmann, University of Utah, recommended that the Carrington fault be temporarily dropped from consideration for priority study. They have already collected some seismic reflection data across it in conjunction with other projects on Great Salt Lake, but have not yet analyzed the data. Upon further discussion, the Working Group ranked the following five faults/fault segments for highest priority study in 2010: (1) northern SLCS, (2) WVFZ, (3) penultimate event Provo segment WFZ, (4) Washington fault, and (5) Roselle segment Great Salt Lake fault. The following table shows the 2010 highest priority fault list and the current study status for all faults/fault segments identified by the UQFPWG as requiring additional study.

UQFPWG 2010 highest priority list of Quaternary faults/fault segments requiring additional study to adequately characterize Utah's earthquake hazard to a minimally acceptable level, and status of current paleoseismic investigations on all Utah priority faults/fault segments.

2010 Highest Priority Faults/Fault Sections For Study			
Fault/Fault Section	**Priority**	**Investigation Status**	**Investigating Institution[1]**
Northern Salt Lake City segment WFZ	1	No activity	
West Valley fault zone	2	No activity	
Penultimate event Provo segment WFZ	3	Trench site reconnaissance	UGS
Washington fault	4	Reconnaissance study	UGS
Rozelle segment, Great Salt Lake fault	5	No activity	
Other Priority Faults/Fault Sections Requiring Further Study			
Fault/Fault Section	**Original UQFPWG Priority**	**Investigation Status**	**Investigating Institution[1]**
Cedar City-Parowan monocline/ Paragonah fault	10	No activity	
Enoch graben	11	No activity	
Clarkston fault	13	No activity	
Gunnison fault	17	No activity	
Scipio Valley faults	18	No activity	
Faults beneath Bear Lake	19	No activity	
Eastern Bear Lake fault	20	No activity	
Bear River fault zone	2007	Scarp reconnaissance	USGS
Faults/Fault Sections Studies Complete or Ongoing			
Fault/Fault Section	**Original UQFPWG Priority**	**Investigation Status**	**Investigating Institution[1]**
Nephi segment WFZ	1	UGS Special Study 124/USGS Map 2966/UVSC study ongoing	UGS/USGS/UVU
Weber segment WFZ – most recent event	3	Ongoing	UGS/USGS
Weber segment WFZ – multiple events	4	Ongoing	UGS/USGS
Utah Lake faults and folds	5	Ongoing	UUGG
Great Salt Lake fault zone	6	Ongoing	UUGG
Collinston & Clarkston Mountain segments WFZ	7	UGS Special Study 121	UGS
Sevier/Toroweap fault	8	UGS Special Study 122	UGS
East Cache fault zone	12	Ongoing	USU
Wasatch Range back-valley faults	14	Ongoing	USBR
Hurricane fault	15	UGS Special Study 119	UGS
Levan	16	UGS Map 229	UGS
Brigham City section – most recent event	2007	Ongoing	UGS/USGS

Note 1 – UGS (Utah Geological Survey), USGS (U.S. Geological Survey), UVSC (Utah Valley University), UUGG (University of Utah Department of Geology & Geophysics), USU (Utah State University), and USBR (U.S. Bureau of Reclamation).

ATTACHMENT 1
Meeting Attendees

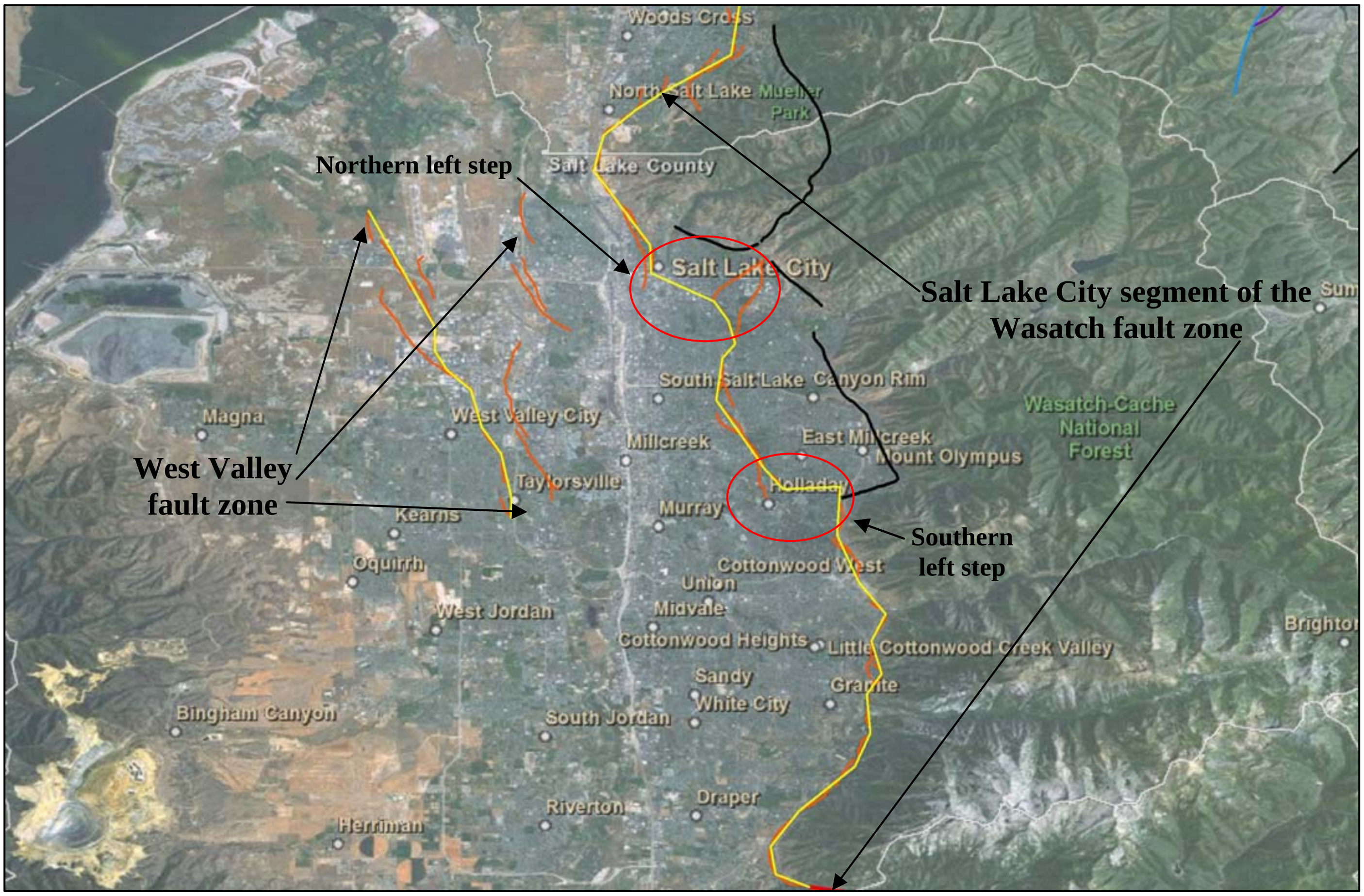
Quaternary Fault Parameters Working Group

Tony Crone, USGS
David Dinter, UUGG
Chris DuRoss, UGS
Daniel Horns, UVSU
Michael Hylland, UGS
William Lund, UGS
Susan Olig, URS Corp.
James Pechmann, UUSS
Steve Personius, USGS
Mark Petersen, USGS
Lucy Piety, USBR (for Larry Anderson)
Christine Puskas, UUGG (for Robert Smith)
Ivan Wong, URS Corp.

Guests

Rick Allis, UGS
Steve Bowman, UGS
Ron Bruhn, UUGG
Bob Carey, UHLS
Wu-Lung Chang, UUGG
Gary Christenson, retired
Craig dePolo, NBMG
Ed Fall, UDWR
Jamie Farrell, UUGG
Steve Harmsen, USGS
Tyler Knudsen, UGS
Greg McDonald, UGS
Jerry Schuster, UUGG
David Simon, Simon-Bymaster, Inc.

ATTACHMENT 2



Surface traces (orange) of the Salt Lake City segment of the Wasatch fault zone and West Valley fault zone from the Quaternary fault and fold database and map of Utah (Black and others, 2003), and the generalized fault traces (yellow) of both faults as depicted on the National Seismic Hazard Maps. Red ovals show location of major left steps in the trace of the Salt Lake City segment (modified from a figure provided by Kathy Haller, USGS).

ATTACHMENT 3

Additional written comments provided by Steve Harmsen, USGS, February 25, 2009.

Regarding Jim Pechmann's primary question in 2009UQFPWGDRAFTSUMMARY.doc, this is for the Utah fault working group to decide. He poses three secondary questions early on:

2. Is it necessary and/or desirable for the fault traces used in the NSHM probabilistic seismic hazard analysis (PSHA) calculations to be continuous?
3. Are there subsurface connections across stepovers in normal faults?
4. What about the NSHM generalizations of the rest of the Wasatch fault—and other normal faults?

I will try to comment on the first of these. Question 2 above asks if fault traces need to be continuous in the NSHMP analysis. The initial answer is that for characteristic ruptures, the software is currently set up to handle continuous faults only. For GR ruptures, the same is true but there are jumps because the ruptures "march along" strike with discrete steps (1 or 2 km steps typically) in their endpoints. You could envision throwing out some of the GR ruptures or otherwise redistributing them in a non-uniform manner along strike and making the GR model more discontinuous by making very modest changes to the software. Something similar has already been tried for the Denali fault in Alaska.

The fact that current code has the above limits does not mean that we could not revise the code to handle faults with discontinuous jumps in the rupture, only that we have not yet done this. Whether desirable should probably be answered by seismologists and geologists who are familiar with Basin and Range rupture processes. It is pertinent to point out, as Bill alludes to in question 3 above, that discontinuous surface-rupture mapping does not necessarily imply a discontinuous rupture process at seismogenic depth; even the possibility of locally accelerated erosion at the surface might have obscured some evidence. What the NSHMP analysis should be given as a desideratum for modeling is the assumed geometry and rake vector of the source at all depths, but especially at seismogenic depths (5 to 15 km approximately), because that is where most of the hazardous vibrations originate. One problem that I can anticipate is that if the fault ruptures to the surface in some places, but does not do so at the jump locations, but is continuous at depth, does the analysis need to include the NGA "buried rupture" terms? The fault rupture is both buried and not-buried depending on where you look along strike. When should we use the "buried rupture" terms that several of the NGA modelers have supplied, not use them, or use some weighted percentage? NGA developers do not address this question in their reports as far as I remember. They treat the 1992 Landers mainshock as surface rupturing even though there are many rupture discontinuities among the many faults that ruptured. The Chi-Chi, Taiwan mainshock rupture was partly discontinuous along the surface, especially where the strike shifts from predominantly north to east. Most fault-slip inversion models use simplified sets of planar welded rectangles (and triangles if needed) to describe the Landers and Chi-Chi rupture surface; that is they ignore the surface discontinuities. The simplifications in the NSHMP fault model are thus akin to typical fault models used in slip-distribution inversion routines. Maybe an acceptable working answer is that if the ratio of surface rupture length to at-depth rupture length is greater than 75% (or whatever) treat event as surface-rupturing (this would probably include almost all such hybrid sources), but if the modeled discontinuities exceed 25% of the total length, include some buried-rupture effects. Whatever decision is made should be made by or in concert with the NGA developer teams to insure that they are on board.

For the possibility that some characteristic events should be modeled with discontinuous behavior both at the surface and at depth, we still ought to be given or agree on a reasonably precise model for at-depth rupture and non-rupture. It is not sufficient to answer Q3 above, 'yes', because we need to know (or assume we know) the entire rupture-surface geometry, not just go where we will given that there might be some degree of continuity at depth (too vague). How should the surface-rupture model be extended downdip in the neighborhood of the discontinuity or jump, along a normal-to-strike vector or along a ramp that may intersect or nearly intersect the next section at some depth?

The possibility of opening up the domain of characteristic ruptures to include discontinuous faults or jumps needs to consider the above and possibly other questions that arise when you open this door. Mathematically, I expect we can handle these new models as long as the rupture zone is well defined, but if too many essential details are left to the programmer, the outcome might not be what is desired. Because these details are in a murky area of great uncertainty, it is hard to anticipate what the answers are or should be. Leaving 'em to programmers to decide seems like a wrong-headed approach or at least an avenue to additional uncertainty.

On a related theme, faults often change strike substantially before the jump, as for example, in the SLC section of the Wasatch fault between the northern East Bench fault and the southern Warm Springs fault. Where the predominant strike changes by more than 50 degrees or so, it makes sense to expect a substantial change in the sense-of-slip as well. If, for example, the primary strike direction of a normal-slip fault is perpendicular to the direction of minimum principal compressive stress, or σ_3, and if the strike locally changes by 90 degrees, the sense-of-slip should probably change to strike slip (normal fault changing to tear fault). This is another complication that we cannot currently handle in the NSHMP software. Our model of faults has a fixed sense-of-slip assigned everywhere along strike. Similarly, a large change in strike probably implies a large change in fault dip, say from 50 degrees to 90 degrees in this example. Again, our code currently assumes a fixed fault dip everywhere along strike, and a fixed depth of fault bottom (typically 15 km) everywhere along strike. All of these need to be more flexibly defined, I believe, if we open the door to jumps in the fault-rupture description. Geologists should give us a complete 3-d description of the fault surface that they believe is going to rupture, along with alternatives if any. The current way of specifying surface trace and dip or dip uncertainty is what led us into trouble with the West Valley fault characterization in previous versions of the national maps, and with several graben-bounding faults in the current version as well.

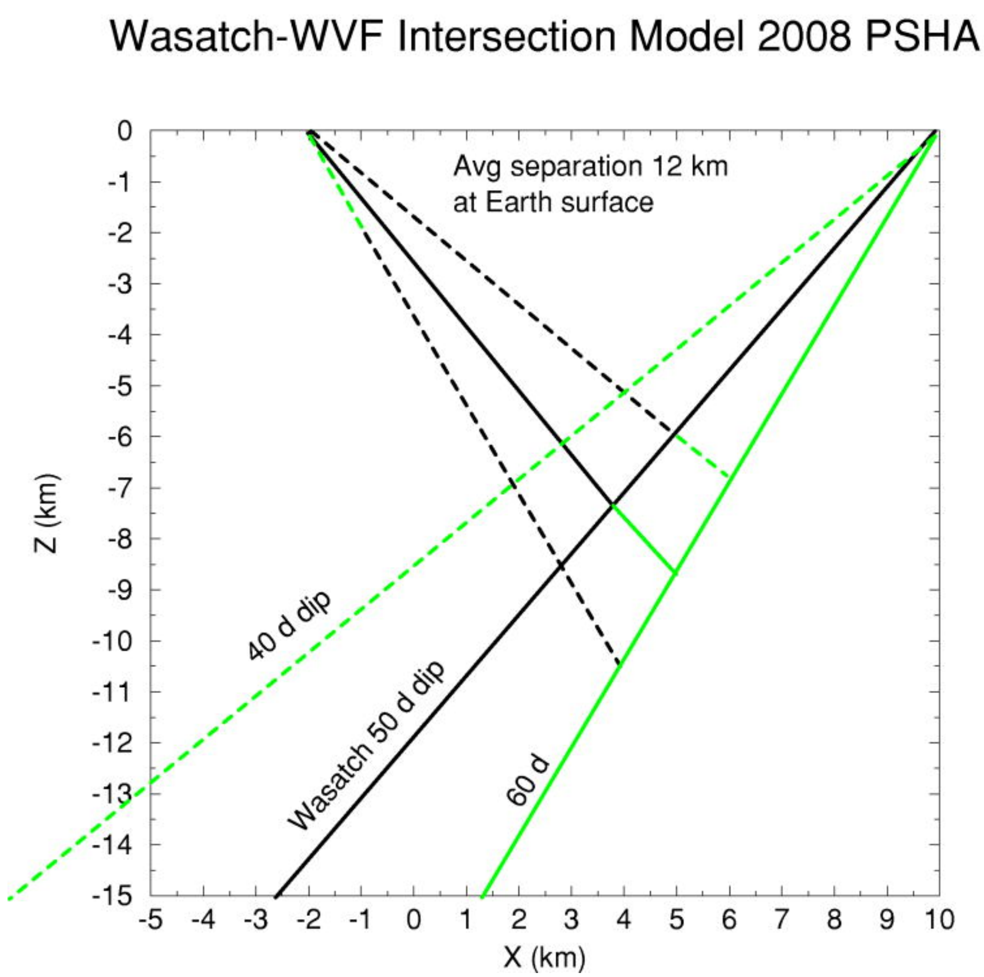
One way that we might attempt to handle the fault-jump problem would be to define clustered events along strike. Some of the events in the cluster could be strike slip and some dip slip, and they could have different dips, fault-segment tops and bottoms, and so on. A potential problem associated with going down this road is that the surface slip per event as measured by geologists might be too large compared to that predicted from the lower-magnitude events that would comprise the elements of the cluster. For example, the Wasatch M7 might turn into a pair of M6.5 normal events or so with a small strike slip event with M of 6 or so. A counter argument is that the slip-per-event regression does not provide a very precise prediction (large variance or data dispersion), i.e., observed slip data might not contradict the new model in a statistically significant way. This is something to think about and maybe devise significance tests. Another problem associated with clustering smaller characteristic events where there was once a single characteristic event is that we don't have code to handle the Gutenberg-Richter floating ruptures on this fault as well. Perhaps there would need to be rules for clustering the GR events too, something we haven't yet considered, or perhaps we could eliminate the GR branches for these faults with permission from the working groups of course, or perhaps the GR branches could have members that fill the gaps. In any case, GR logic-tree branches occur almost everywhere that characteristic-event branches occur, so that joint revision of GR with characteristic-rupture characterization is an important topic that needs to be addressed. Or we might leave the current GR model alone, and try to initially confine our attempted improvements to the characteristic-source branches. Advice on this might be solicited from the Utah working group.

One possibility is that various somewhat contradictory fault geometries are not necessarily mutually exclusive. That is, along some logic-tree branches certain geometries could be honored and along others, other geometries could be honored (and this could be aleatory or epistemic). I am thinking about the M7.4 *uber*-event on the Wasatch that is given 10% weight in the NSHMP 2008 model. This *uber*-event (if it ever happens and we don't know if it will) might proceed along a straighter path than the smaller clustered events envisioned in the previous paragraph. There is very limited global experience with M7.4 normal-slip events, and it is not clear that a Wasatch M7.4 would necessarily behave like some "global-analog" example that might be provided. Nor is it clear that it would occupy the same sub-faults as smaller ruptures.

Kathy Haller and/or others would have to answer Q4 above. I was not involved in any of those fault-simplification or fault-bridging decisions. One thing that everyone should keep in mind is that the California fault descriptions in our hazard model are much, much straighter than the faults outside California, especially Basin and Range faults. Whether these systematic differences make sense should be explored by geologists (or maybe it has been and I wasn't in on the conclusions).

A philosophy question that comes to mind is, how detailed should the national maps be versus, should important site-specific studies be performed that model more detail in fault ruptures and related issues? It may be that we are placing too much burden on the national maps to go into great detail about all or most of the jigs and jags in Basin and Range faults. A contrary argument is that computer processing is cheap, so we should be able to handle these intricately defined models if they are presented to us in sufficient detail, and a second more theoretical argument is that the quality of the total hazard estimate is a function of how well all of the itsy-bitsy details are handled. We do not have a criterion for simplifying Nevada and Utah fault-trace descriptions the way California working groups seem to have for California faults. Simplifying seems like a useful step in many ventures and we might want to think about ways to simplify Basin and Range fault descriptions without losing the essential hazard implications. There are always conflicts between getting the details right and getting the big picture right, such as, how do you allocate very limited manpower to a long list of time-consuming tasks. I am confident that the questions in this paragraph won't be settled overnight.

Regarding the final 2008 NSHMP treatment of West Valley fault, I mentioned in my power-point presentation that the intersection depths with Wasatch are simple trigonometric functions of the assumed separation of the faults (we used 12 km for the 2008 maps) and the assumed dips. The resulting intersection depths ranged from 5 to 10 km approximately (see below). A closer separation, such as the 8 km that is suggested by active fault trace locations would reduce these depths by 1/3, a very substantial amount, as well as reduce the WV fault area and implied event-rate distribution by 1/3. The 12-km separation is based on trace locations of possibly less-active fault traces. Applying this relatively large separation in the hazard calculations might be justified if we believe that some of the more active traces are listric faults with very steep dip near the Earth surface, and that the primary fault surface would project out further if linearly extended from the intersection depth, as in the figure.



ATTACHMENT 4
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